Suction device

This invention relates to plunger operated liquid dispensers, such as manual pipettors, which are used to dispense liquids. Specifically the invention relates to reliable removal of a liquid from the liquid dispenser. Especially preferable the invention is in such liquid dispensers, which are used to handle relatively small sample amounts, such as around one microliter. More specifically the object of the invention is what is said in the preambles of the independent claims.

Plunger operated liquid dispensers normally have a function which is called a blow-out. Therein the movement of the plunger while removing a liquid (secondary movement) is longer than the movement which has been made by the plunger while receiving the liquid. Thus removal of the liquid can be improved when compared to the situation when the plunger would move the same distance in both the receiving and removal phases. In manual pipettors this function is usually accomplished by two springs, whereas in electronic pipettors this function is possible to accomplish simply by continuing the movement of the plunger with the help of a motor. In both approaches only one plunger is used.

Above mentioned removing problem emphasizes with small volumes when the diameter of the plunger is small in relation to the removal opening of the tip. What usually happens is that the liquid is not removed from the tip but it revolves to the outer surface of the tip. Then the liquid drop must be mechanically removed by the user by transfering the liquid mechanically to a wall of the tube which is receiving the sample. Usually the out pipetting is repeated several times. Another solution is to saturate the sample to a liquid already existing in the tube. In the end it is always up to carefulness of the person performing the pipetting how well the liquid actually tranfers and how much still remains in the tip. Naturally these kind of different contacts also results in that different contamination risks increase.

More generally the weakness in pipettors can be said to be this difficult pipetting of small portion volumes. The volumes below 10 µl do not come off from the pipettor tip, whereat they must be pipetted saturated in a liquid or they must be able to make that catch in the wall of a test tube. This has resulted in that manual pipettors are used when small volumes are pipetted because manual pipettors enable several removals successively. However, the accuracy is then quite poor.

The international standards allow large CV percents for 0,1-2 µl volumes. However, smaller volumes usually are portion volumes of a test sample which determine the accuracy of the whole test. These standards are clearly drafted taking into consideration the problem caused by the small plunger diameter.

In automatic dispensers which require that different tip must be used for each sample can not dispense small volumes, which results in that a lot of reagences must be used. In addition if a sample is tried to make a catch to the bottom of a test tube/plate with these automatic dispensers the accuracy of the structure of this kind of device must be controlled extremely well, and in the worst case the situation is such that a bad accuracy appears occasionally.

In turn, in hand held pipettors, especially in 10 µl pipettors, the problem is different attachment of the tips, because of that the catch of a sample to a test plate is extremely difficult.

One approach is to use two nested plungers. The inner plunger is a portioning plunger whose movement distance defines the volume to be dispensed. The movement of this portioning plunger is the same while receiving the liquid and while removing it. The outer plunger is a blow-out plunger, which starts it´s movement only after the portioning plunger has carried out it´s removal movement.

Another approach is to use two plungers so that these two plungers act simultaneously during the removal, then more pressure is developed to a tip of the pipettor. Even the smallest drops which tend the remain in the tip are aspired to be removed from the tip.

Based on what is said above now has been noticed that the removing problems of the liquid relate to the slow movement of the plunger during the removal phase. The purpose of this invention is thus to develop further the function of the pipettors in situations where a tip of the liquid dispenser is aspired to be emptied so that there is no need for contact with a test tube or with a liquid, and that dividing of the liquid between the tube and the tip remains the same between portionings.

The teaching of the present invention in relation to the before mentioned state of the art is that the movement of the plunger of the liquid dispenser is fastened during removal of the liquid.

This change in speed is preferably sudden, when the sample is as it were launched out from the liquid dispenser. More specifically the invention is characterized in that what is said in the characterizing parts of the independent claims. Some preferable embodiments are presented in the dependent claims.

Thought behind the invention is that the sample is portioned with one plunger in a way that the plunger is a small diameter plunger in a receiving phase and a large diameter plunger in a removal phase. The seemingly larger diameter of the plunger is provided with a multiple movement speed. The movement speed can be used in the most preferable phase to optimize portioning. The high movement speed and it´s activation can be accomplished with several technical components.

Electrical hand held pipettors are known to have such adjustment possibilities that the movement of the plunger can be adjusted using programs. This intrinsically is obvious for a person skilled in the art through experimentation so that an optimal movement speed can be achieved for the plunger. These previously known electrical pipettors however do not make difference between the receiving and removal phases so that the removal movement speed would be fastened to solve this particular problem that especially with small volumes during the removal phase the sample tends to revolve to the outer surface of the tip. Also the previously known motors do not present such motors which could produce sufficient speeds.

Previously mentioned optimatization of the movement speed of the plunger is a substantial part of the present invention. It is important that the receiving suction is carried out slowly and the removal movement is carried out with high speed. After what is said here it is obvious for a person skilled in the art that the mentioned removal movement speed can be achieved with several different ways. According to the invention the liquid dispenser comprises such means which enable the removal movement of the plunger to be increased very high. With the help of such a fast removal speed the liquid dispenser tip always empties similarly, when the CV percent is comparable also with small volumes.

According to one embodiment of the invention the previously mentioned means comprise spring like means, energy means, which produces the energy needed by the removal movement. Here it must be noted that the spring like means is very preferable but such energy can also be produced also in a different way, for example in case of an electrical pipettor by pro-

gramming. Preferably such spring like means can be for example a spring, or for example a combination utilizing magnetic forces. According to this embodiment the spring like means must be activated, after which activation this activation must be locked with suitable means. Such activation can be implemented, again as an example, using magnetic forces. Naturally this embodiment also requires means which can release the said activation. Such relase means can be for example a mechanical trigger which may utilize the possible magnetic forces.

According to one preferable embodiment the liquid dispenser is an electronical pipettor, such as for example a Biohit eLine -series pipettor. A pipettor comprises a cylinder part which is adapted inside a body, inside which cylinder part a plunger moves to dispense liquid. The plunger has a normal relatively slow movement speed produced by the motor. To implement the invention the pipettor is equipped with launch means. These launch means comprise an actuator shaft, which is preferably made of magnetic steel. In addition the launch means comprise a spring, a magnet and activation means, which is preferably an activation pin, or similarly functioning mechanical response. To carry out the invention the shaft gets into contact with the magnet. Then the launch spring is activated. After this the sample is received normally by moving the plunger upwards. When the required liquid volume has been received, the plunger stops. When the liquid needs to be removed from the sample space, the motor starts again an upward movement. When the movement continues upwards the launch pin comes into contact with a response which is preferably provided in the pipettor body. When the movement continues upwards, the launch pin forces the actuator shaft apart from the magnet, whereat the spring forces the actuator in a fast downward movement, resulting in that the actual suction plunger causes fast movement of the liquid from the sample space when moving downwards, and whereat the liquid does not revolve to the outer wall of the tip but is entirely removed from the tip, which is for example a detachable disposable tip.

Another embodiment is a hand held mechanical pipettor where the present invention is utilized. In a mechanical pipettor the activation of an energy means can be carried out for example similarly as described above during a downward movement of a plunger, which movement can be for example a blow-out movement. After this the sample is received normally. Finally the energy means is launched with appropriate means. Such appropriate means can be for example a trigger provided in the pipettor body.

In the folowing reference is made to the attached drawings where is presented one way for implementing the invention. In the drawings:

Fig. 1 depicts a simplified cross section drawing of a hand held pipettor;

Fig. 2 depicts slightly more details of the pipettor of Fig. 1; and

Fig. 3 presents pictures a-d which depicts pipettor of Fig. 2 in action.

Similar numbering is used throughout the figures for the parts which are included in several figures. Pipettor 10 comprises an inner actuator shaft 1, a spring 2, a magnet 3, a launch pin 4, an upper response 5, a suction plunger 6, a function plunger 7, a cylinder 8, a motor 9, a disposable tip 11 and a launch means body 12.

The actual actuator implementing the present invention comprises in these figures the actuator shaft, the magnet and the launch pin.

The suction plunger is connected to the actuator shaft, which is connected to the function plunger by the magnet. When the motor moves the function shaft upwards these three (1, 6, 7) move together and the suction shaft moves inside the cylinder causing the suction function for receiving a sample to the tip. The spring is arranged between the response in the actuator shaft and the launch means body. The magnet is solidly inside the launch means body, and the actuator shaft is arranged to move inside the launch means body. The launch pin is arranged so that when it comes into contact with the upper response arranged in the pipettor body, it forces the actuator shaft apart from the magnet inside the launch means body.

The object of the invention is that the volume to be portioned is launched out with high speed. When implementing the structure it is important that the home of the suction plunger is located so that the suction movement fits before the launch point. This home is especially presented in Figure 3a. Then according to the invention the sample is received in the tip, which position is presented in Fig. 3b. After this the motor is driven slightly more upwards whereat the launch pin contacts the upper response and pushes the actuator shaft apart from the magnet. The contact between the launch pin and the upper response is also presented in Figure 3b. When the actuator shaft has aparted from the magnet, the spring forces the plunger to shoot downwards with high speed as is presented in Fig. 3c. In hand held electronic pipettors removal of the tip can be preferably carried out during the activation of the actuator for a new suction function. Such activation of the actuator is presented in Fig. 3d, where the motor

pushes the launch means body with the help of the function plunger downwards and thus the magnet is again in contact with the actuator shaft.